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ROLE OF NUCLEAR POWER IN UKRAINE*

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Nuclear power of Ukraine commenced from Chornobyl NPP, where the first unit was put into operation at 1977. At present in Ukraine there are 4 running NPPs with a total installed capacity 11880 MW where more than 40 % of electricity is generated. Elaborated Atomic Energy Strategy Development for the period till 2030 after the commissioning of two new units in 2004 foresees to keep the total installed capacity around 14000 MW. Analysis on the maintenance of such level and the solution of other problems, related to nuclear energy is carried out. Among them: nuclear fuel cycle, handling of radioactive wastes, decommissioning and others. Thus nuclear energy plays and will play the important role to ensure the electricity generation in Ukraine.

1. Introduction

Energy structure of Ukraine was formed during the decades and was determined by energy policy of the former USSR in creation of the unique energy system. Ukraine can comply its energy demand only partially, based on its own organic fuel resources. To cover the energy deficit, the course on nuclear power development in the country was adopted. Nuclear era in Ukraine started from Chornobyl Nuclear Power Plant (NPP), the first unit of which was commissioned in 1977. This event was followed by the construction and commissioning of other units of Chornobyl NPP and new NPPs.

Accident at Chornobyl NPP in 1986 was a great trial for nuclear power development in Ukraine. Negative attitude to nuclear power appeared within the considerable part of Ukrainian society. Nevertheless during the difficult post-accident period some of them were constructed and their readiness for operation was very high.

At the end of 1986 the power unit 3 of Zaporizhzhya NPP and power unit 3 of Rivne NPP were commissioned. And in 1987 the unit 4 of Zaporizhzhya NPP was put in operation, as well as the unit 3 of this NPP was decommissioned after Chornobyl accident. The construction of unit 4 at Rivne NPP and unit 2 at Khmelnitsky NPP started in 1986. At the late 80-ies both they were in high readiness. However, under the strong social pressure the Supreme Council of Ukraine adopted the moratorium on the construction of new reactors in 1991. And in spite that this moratorium lasted only till 1993, its consequences have led to the considerable economic losses that are visible up to now. Commissioning of the new power units at Khmelnitsky and Rivne NPPs is planed during the current year.

It is well known that under the pressure of world-wide community Ukraine has made an unprecedented step – shut down the Chornobyl NPP in 2000. This act was realized under the guarantee of "Great Seven" countries to assist in final construction of the new units that could compensate energy deficit. However, this did not happen and Ukraine itself is continuing the construction of Khm-2 and Riv-4 power units.

2. Current situation of nuclear power in Ukraine

Chornobyl NPP is decommissioned. Last unit with RBMK-1000 reactor type was finally shut down on December 15, 2000.

At four running NPPs (Zaporizhzhya, Rivne, Khmelnitsky and South Ukraine) 13 power units are in operation: 11 with reactors of WWER-1000 type and 2 – with WWER-440 type (table).

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NPP title	Unit number	Reactor type	Installed energy capacity, MW	Beginning of construction	Unit start-up	Completion of design operation period
Zaporizhzhya	1	WWER-1000/320	1000	04.1980	10.12.1984	10.12.2014
	2	WWER-1000/320	1000	04.1981	22.07.1985	22.07.2015
	3	WWER-1000/320	1000	04.1982	10.12.1986	10.12.2016
	4	WWER-1000/320	1000	01.1984	18.12.1987	18.12.2017
	5	WWER-1000/320	1000	07.1985	14.08.1989	14.08.2019
	6	WWER-1000/320	1000	06.1986	19.10.1995	19.10.2025
South Ukraine	1	WWER-1000/320	1000	03.1977	31.12.1982	31.12.2012
	2	WWER-1000/338	1000	10.1979	06.01.1998	06.01.2015
	3	WWER-1000/320	1000	02.1985	20.09.1989	20.09.2019
Rivne	1	WWER-440/213	415	08.1976	22.12.1980	22.12.2010
	2	WWER-440/213	420	10.1977	22.12.1981	22.12.2011
	3	WWER-1000/320	1000	02.1981	21.12.1986	21.12.2016
	4[a]	WWER-1000/320	1000	1986		
Chornobyl	1[b]	RBMK-1000	800	06.1972	26.09.1977	
	2[b]	RBMK-1000	1000	02.1973	21.12.1978	
	3[b]	RBMK-1000	1000	05.1977	03.12.1981	
Khmelnitsky	1	WWER-1000/320	1000	11.1981	22.12.1987	22.12.2017
	2[a]	WWER-1000/320	1000	1986		

[a] Unit on the stage of construction completion.
[b] Finally decommissioned unit.

Within NPPs installed capacity (11880 MW) Ukraine is taking the 8-th place in the world and the 5-th place in Europe.

The energy production dynamics at NPPs in comparison with total energy production in Ukraine for the last ten years is shown in fig. 1.

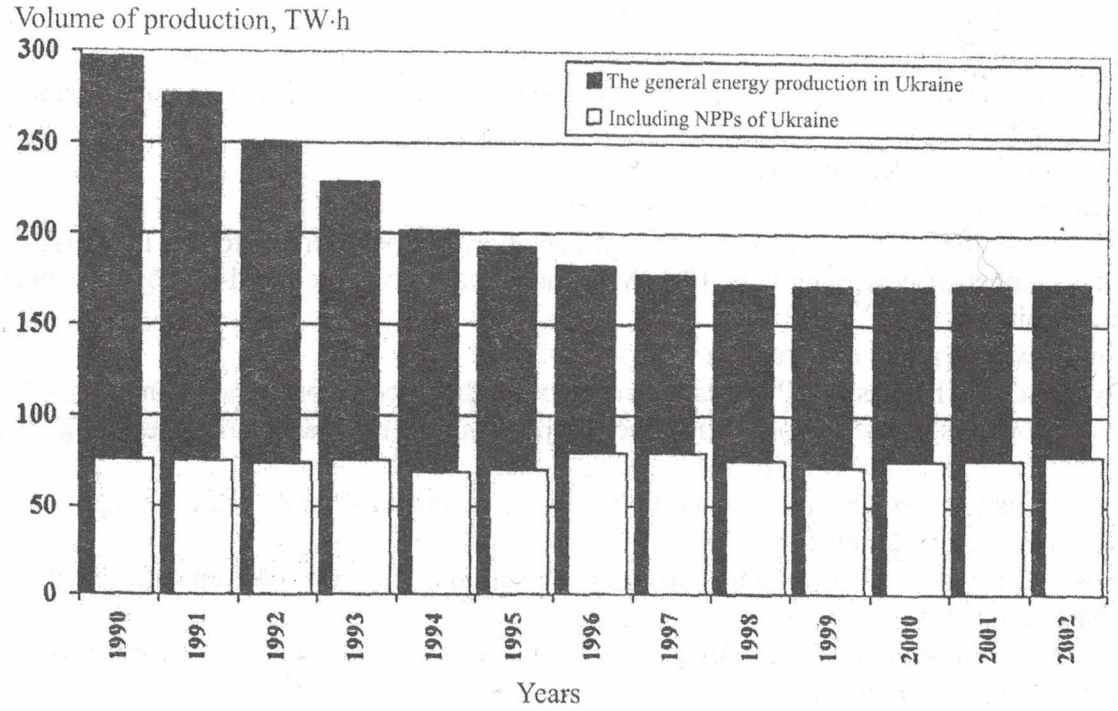

Fig. 1. Energy generation in Ukraine during 1990 – 2002.

As it can be seen in the figure during the long period nuclear power complex provides an essential part of total energy production in Ukraine (more than 40 %), and this makes the stable functioning of energy sector as an important pre-condition for the stable economic development in the whole country.

The design term of power unit WWER-440 and WWER-1000 operation is 30 years. The planned terms of reactor operation are indicated in correspondence with designs (see table). Starting from 2011 measures on decommission have to be commenced. Meanwhile the world practice and preliminary evaluations of actual operating NPP unit conditions indicate the potential possibility of their operation prolongation beyond the design limits.

Construction and commissioning of the new reactor are expensive and take a lot of time. Therefore, there is an urgent need to find future approaches to nuclear power. This was done in the frames of energy strategy development in Ukraine for the period till 2030 and its further perspectives according to the President of Ukraine Provision dated February 27, 2001. The draft of the mentioned Strategy was developed in the end of 2003 and is presented to the consideration of the Government.

This given document contains a separate section devoted to the nuclear power development strategy till 2030 and further perspectives [1 - 3].

3. Strategy of nuclear power development in Ukraine

The crucial point of this strategy is prolongation of reactor operation resource for 5 - 15 years after termination of 30-years design period. The second important element is the position according to which the total installed NPP capacity will be maintained up to 2030 at the reached level of 14000 MW after commissioning of two power units in Khm-2 and Riv-4.

Three scenarios of nuclear power development are considered:

Scenario-1 which corresponds to the maximum prolongation of operating NPP's work assumes:

duration of existing nuclear power unit operation will be extended for 10 - 15 years;

total number of new units with 1000 MW modal capacity which will be commissioned to 2030, are 7 units (including Riv-4 and Khm-2);

4 units will be under construction in 2030.

Scenario-2 supposes:

duration of all nuclear power unit's operation will be prolonged for 10 years;

total number of new units with 1000 MW modal capacity which will be commissioned to 2030, are 11 units;

3 units will be under construction in 2030.

Scenario-3 predicts:

duration of the existing nuclear power unit operation will be extended for 5 - 10 years;

total number of new units with 1000 MW modal capacity which will be commissioned to 2030, are 11 units;

3 units will be under construction in 2030.

Dynamics of changes in NPP installed capacity for three scenarios is shown in figs 2 - 4.

Right now it is necessary to organize the complex works on replacement for existing nuclear power plants. Main requirements are the following:

reactor installation which is planned for construction should satisfy to all existing in Ukraine safety standards and regulations;

power unit with selected reactor has to be created and must have the operation experience not less than three years in any country;

economic indicators of the energy generation at such power unit should be competitive with regard to traditional power plants;

reactor should have such safety systems that will make impossible active zone core melting at any accident;

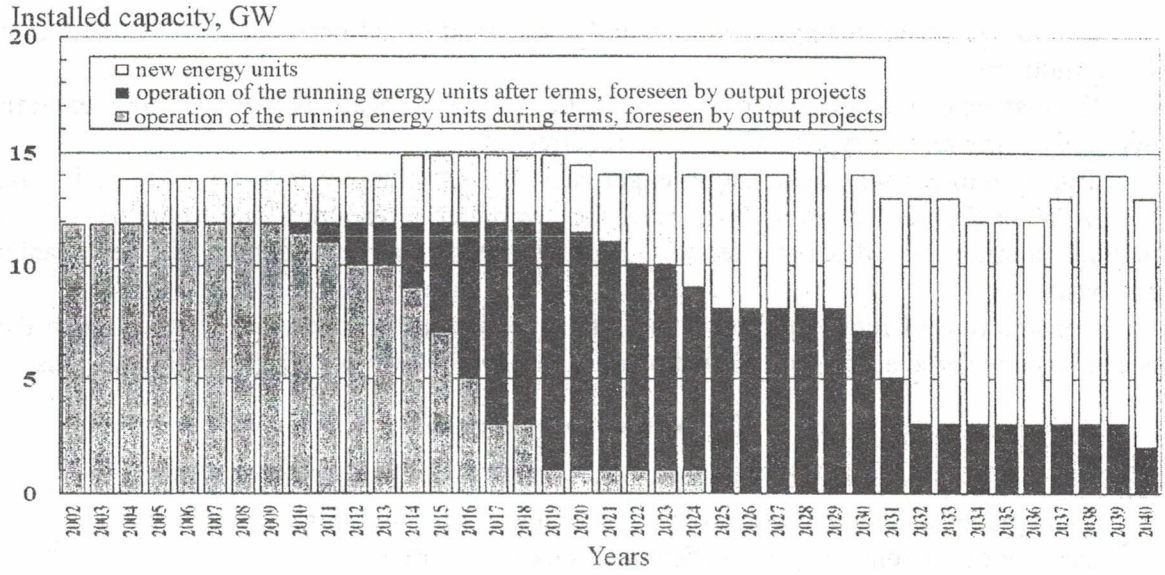

Fig. 2. Scenario-1. Dynamics of changes on NPP installed capacity.

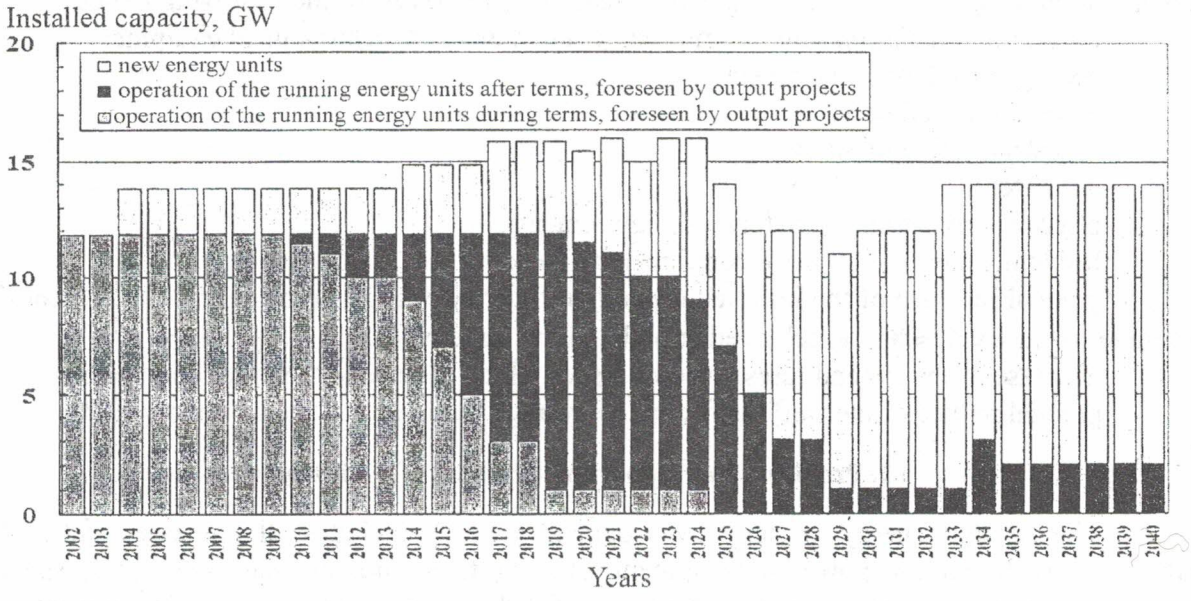

Fig. 3. Scenario-2. Dynamics of changes on NPP installed capacity.

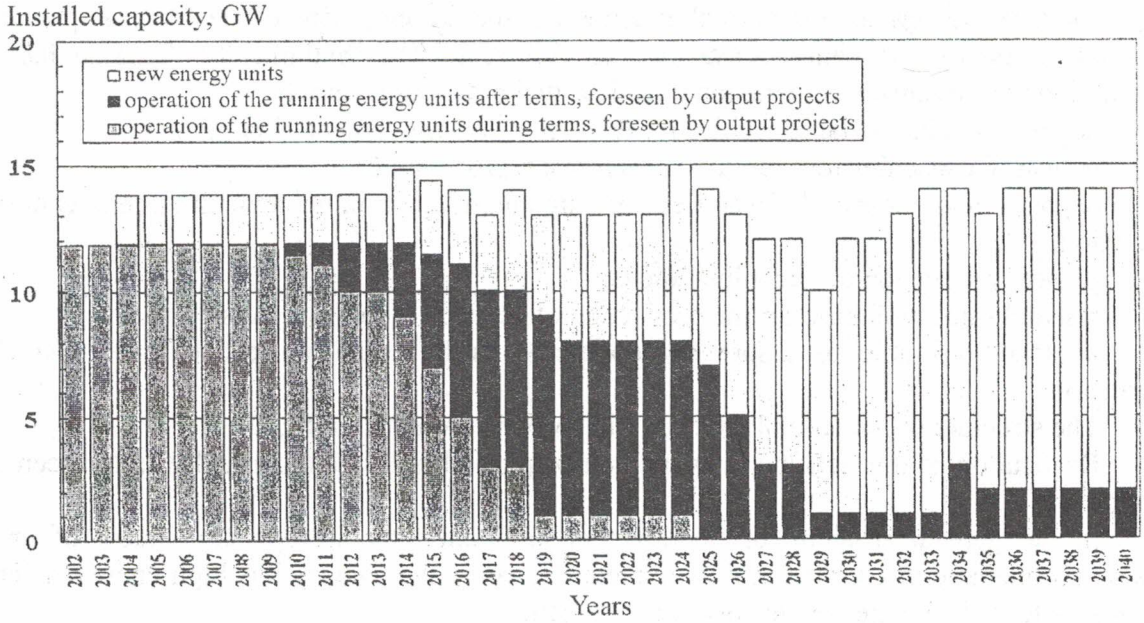

Fig. 4. Scenario-3. Dynamics of changes on NPP installed capacity.

technology of reactor production should correspond to the needs of the Ukrainian machine-building industry.

Final stage of reactor choice is ecological expertise, as State as well as public expertise. At present only some reactor types satisfy these requirements.

Taking into account the existing experience, the most appropriate for Ukraine is advanced reactor of WWER type. However considering the raw material resources in the country, the reactors on natural uranium also deserve attention. Final choice of reactor selection will be organized on tender base.

Construction of replacing power units is supposed to be at existing sites. Though the new sites can be considered at the regions that practically have no own power generating sources.

3.1. Work of operating NPPs

The principal tasks of NPP operation according to the adopted Strategy are:

maintenance and increase of safety level of nuclear power units;

increase of the reliability and efficiency of existing NPPs.

Strategically the main ways for solution of these problems are full-scale financing and organizational support in maintaining and increasing of the levels of the following issues:

nuclear and radiation safety of nuclear installations and technological equipment;

ecological safety of the objects;

emergency readiness;

industrial safety of all units;

fire safety;

physical protection and safeguard requirements.

Implementation of all these conditions will lead to:

gradual increase of the installed capacity efficiency coefficient from 75 % at present till the average world level (≈ 85 %) achieved at NPPs of the same type;

decrease of the expenditures on some issues which determine the production price;

gradual reduce of the staff coefficient to average world level (around 1 man/MW).

3.2. Problems and supporting branches of nuclear power

The Atomic Energy Strategy Development (AESD) includes all processes and problems which go with nuclear power development. Among them are: nuclear fuel cycle; spent fuel management; radioactive waste management; NPP decommissioning; scientific-engineering and design-construction support of nuclear power complex; the personnel for nuclear power.

Nuclear fuel cycle. For normal functioning and development of the nuclear power it is necessary to provide it with nuclear fuel in full scale and rhythmically. Ukraine has good preconditions for organization of national nuclear fuel production namely:

deposits and industrial capacities for extraction and enrichment of uranium ore;

industrial capacities for uranium concentrate reprocessing;

deposits and industrial capacities for zirconium ore mining and zirconium concentrate production;

pioneer production of zirconium alloys;

research-industrial base for the production of needed component parts;

organizations able to assure appropriate scientific-technical, technological and design supervision.

The structure of the possible nuclear fuel cycle is presented in fig. 5.

Realization of this scheme is available and profitable for Ukraine and it is foreseen in the strategy.

In the general structure of nuclear fuel production the isotope enrichment of uranium remains problematic in Ukraine at this moment. However the country has high enough scientific-technical potential who are able to solve this problem.

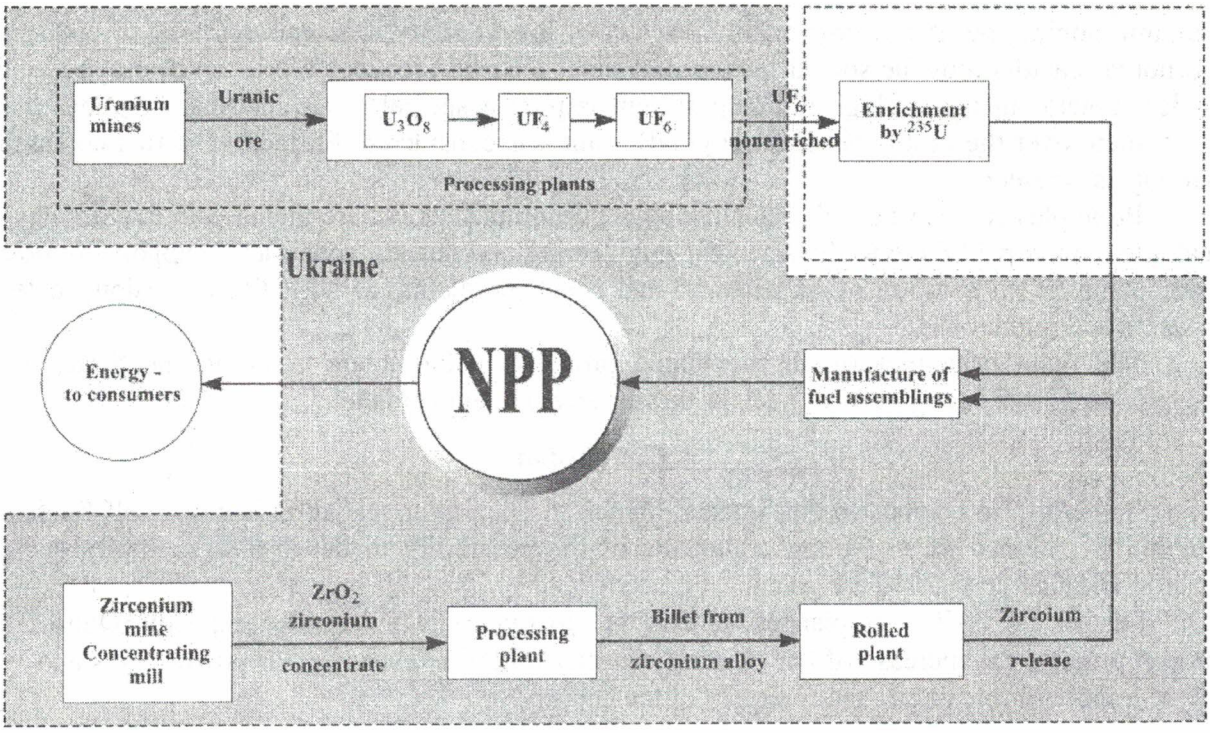

Fig. 5. Scheme of nuclear fuel cycle in Ukraine.

Spent nuclear fuel. The problem of spent nuclear fuel should be also solved. At present open nuclear fuel cycle is organized in Ukraine. Fresh nuclear fuel is supplied from Russia. Spent nuclear fuel from reactors after preliminary storage in the pre-reactor ponds is sent for intermediate storage and following processing to Russia. During the last years some complications appear with this nuclear fuel, in particular, costs of its transportation and processing permanently enhance. But pre-reactor pond capacities at Ukrainian NPPs are gradually exhausted, and therefore the additional measures are undertaken to assure spent fuel storage.

Program of spent nuclear fuel storage is also aimed to construction of dry storages at sites of each NPP and then the creation of the centralized spent nuclear fuel storage. Its creation will considerably solve the problem of temporary spent nuclear fuel storage.

Radioactive wastes. No less important problem for the country having NPPs is the problem of reprocessing and the utilization of radioactive wastes (RW). During NPP operation liquid and solid RW are formed, and they are stored for some period at NPP.

Yearly increase of RW volumes in Ukrainian storages is in average 4 - 6 % for solid and 11 - 13 % for liquid wastes from the volumes of design storage. At such rate of volumes filling in the nearest years the problem of power unit operation can be very serious.

With regard to this fact, in the frame of Chornobyl NPP decommissioning, the construction of the plant for liquid RW reprocessing, extraction of solid wastes and the plant for their reprocessing and short term RW storage is planned. Besides, in connection with the Complex program of safe RW management in exclusion zone, the construction of "Vector" building is underway, and its first line should be ready very soon. However all measures concern the RW handling only for a comparative short period of time.

The most complicated and not yet solved problem is handling with long-term and high-active wastes. In accordance with legislation the AESD program foresees that such wastes should be placed in the stable geologic formations for the permanent disposal. One of possible places for geologic storages is the exclusion zone. But final solution of this issue requires prompt and fundamental research, since the creation of geological storages will last decades, through RW problem is existing today.

Nuclear power plant decommissioning. Long-term programs of nuclear energy should plan and solve problems of NPP decommissioning. There exists experience in nuclear installation

decommissioning, but it concerns mainly reactors of low capacity. Decommissioning of 1000 MW Chornobyl reactors must be solved for the first time in world practice. Works on destroyed by the accident reactor in the ecologically safe system require a special program. Now creation of the confinement over the destroyed Chornobyl NPP unit 4 is considered. Extraction of fuel containing materials is foreseen.

Principles and ways of other nuclear object decommissioning are included in the Strategy. A great attention is paid there to the scientific engineering and design- constructor support of nuclear power complex, to solution of its personal and social problems, to NPP life extension, to legal standards and regulations.

The main principles of all mentioned problems solution are given in the Strategy. A thorough economic background of nuclear power development is made.

4. Conclusion

It is worth to emphasize that nuclear branch of Ukraine is self-sufficient and self-financing principle is included there. Strong arguments of the possibility to develop successfully nuclear power in Ukraine up to 2030 are given.

Further till 2050 it is planned at least not to reduce NPP installed capacity. One of the versions predicts the increase of the existing capacity to 25 %. Thus nuclear power plays and will play an important role in electricity supply of the country.

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РОЛЬ АТОМНОЇ ЕНЕРГЕТИКИ В УКРАЇНІ

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Атомна енергетика в Україні розпочалась з Чорнобильської атомної станції, на якій у 1977 р. було запущено в дію перший блок. Зараз в Україні чотири діючі АЕС із загальною встановленою потужністю 11880 МВт, на яких виробляється більше ніж 40 % електроенергії. Розроблена Стратегія розвитку атомної енергетики на період до 2030 р. передбачає підтримку загальної встановленої потужності до рівня 14000 МВт після введення в експлуатацію в 2004 р. двох нових блоків. Проведено аналіз щодо підтримки такого рівня виробництва, а також здійснюється вирішення інших проблем, пов'язаних з атомною енергетикою, а саме: ядерно-паливний цикл, поводження з радіоактивними відходами, зняття з експлуатації. Таким чином, атомна енергетика відіграє та буде відігравати важливу роль для забезпечення виробництва електроенергії в Україні.

РОЛЬ АТОМНОЙ ЭНЕРГЕТИКИ В УКРАИНЕ

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Атомная энергетика в Украине началась с Чернобыльской атомной станции, на которой в 1977 г. был запущен в действие первый блок. Сейчас в Украине четыре действующие АЭС с общей установленной мощностью 11880 МВт, на которых вырабатывается более чем 40 % электроэнергии. Разработанная Стратегия развития атомной энергетики на период до 2030 г. предусматривает поддержку общей установленной мощности до уровня 14000 МВт после введения в эксплуатацию в 2004 г. двух новых блоков. Проведен анализ по поддержке такого уровня производства, а также осуществляется решение других проблем, связанных с атомной энергетикой, а именно: ядерно-топливный цикл, обращение с радиоактивными отходами, снятие с эксплуатации. Таким образом, атомная энергетика играет и будет играть важную роль для обеспечения производства электроэнергии в Украине.

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